Simulation of Reservoir Rock Formation: Sedimentation, Compaction, and Diagenesis

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RESEARCH OBJECTIVES

The microstructure of sedimentary rock determines its transport, electric, and mechanical properties. An efficient rock modeling procedure would enable characterization of the pore space geometry and compute the desired macroscopic properties of the rock. The objective of this project is to develop methods for modeling the formation of sedimentary rocks suitable for prediction of rock-transport properties directly from analysis of microscopic pore-space geometry.

APPROACH

The dynamic geologic processes of grain sedimentation and compaction are simulated by solving a dimensionless form of Newton's equations of motion for an ensemble of grains. The Lattice-Boltzmann method is used to simulate viscous fluid flow in the pore space of natural and computer-generated rock samples.

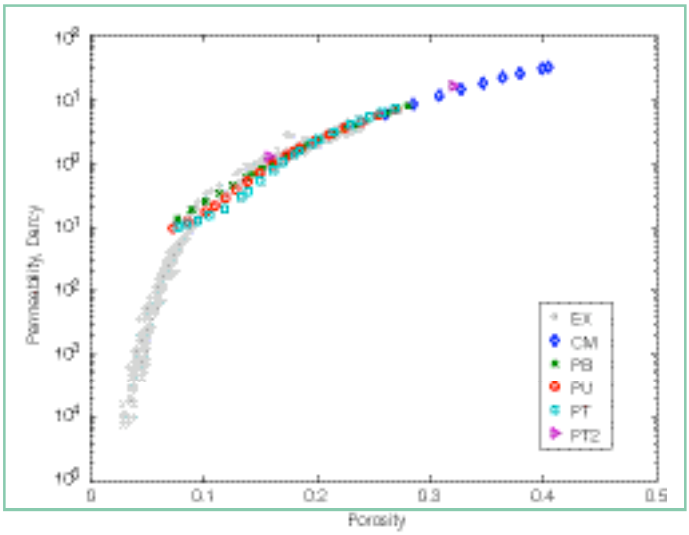

Figure 1. The evolution of absolute permeability of the modeled unconsolidated Fontainebleau sandstone with progressive compaction (CM), various modes of cementation (PB, PU, and PT), and different diagenetic history (PT and PT2), and the measurements on the real Fontainebleau sandstones

ACCOMPLISHMENTS

An integrated approach for estimating the absolute permeability of unconsolidated and consolidated reservoir rock has been developed. This procedure consists of two major steps: (1) obtaining an image from a computed tomography (CT) scanner or simulation of sedimentary rock formation; and (2) simulating viscous fluid flow in the pore space of a tomographic or computer-generated rock image. The results are confirmed by the quantitative comparison of computed permeability with experimental data. The computations-based porosity-permeability relationship of the modeled Fontainebleau sandstone is in good agreement with the laboratory measurements in real rocks (Figure 1).

SIGNIFICANCE OF FINDINGS

Our approach can be used to study the evolution of sedimentary rock porosity, permeability, and strength during arbitrary rock deformations and fracturing. The obtained knowledge can be used to predict rock properties from the grain size distribution and diagenetic history. The crucial factors controlling rock properties can be identified by running various "what-if" simulations. Our model is particularly suitable for analysis of unconsolidated sands whose cores or microtomographic images cannot be obtained.

RELATED PUBLICATIONS

Jin, G., T. Patzek, and D. Silin, Dynamic reconstruction of sedimentary rock using the distinct element method. SPE Journal (submitted), 2004. Berkeley Lab Report LBNL-55038.

Jin, G., T. Patzek, and D. Silin, Direct prediction of the absolute permeability of unconsolidated and consolidated reservoir rock. SPE Paper 90084, Presented at SPE Annual Technical Conference and Exhibition, Houston, Texas, 2004. Berkeley Lab Report LBNL-55339.

ACKNOWLEDGMENTS

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